Comparison of Meaningful Sound vs No Sound for Avoiding Attention Drifting Phenomenon While Driving

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***Abstract*— One of the causes of traffic accident is attention drifting while driving. Attention drifting is also known as habituation phenomenon. Habituation phenomenon refers to a situation where one's attention would decay and possibly diminish over time due to repetitive stimuli. Hence, the aim of this study is to investigate the types of sound that can avoid attention drifting while driving. Using a driving simulation system, the subjects will be simulated with two conditions while driving: no sound and recorded speech. It was found that drivers encounter less accident while listening to the recorded speech compared to the silent condition (no sound). This finding could be used as a foundation to develop tips or methodology to avoid the attention deficit while driving.**

***Index Terms*— Habituation, Attention drifting, Meaningful sound**

I. INTRODUCTION

Malaysia loses RM10 billion every year due to road accident. Statistics and research from Malaysian Institute of Road Safety Research (MIROS) reported 7000 deaths due to road accident each year and it is ranked as the fifth among other causes of death [1]. Many strategic projects and interventions such as AES project, OPS *Sikap*, and others have been implementing to reduce the accident, but the accident continues to rise. Various causes of road accident have been identified, such as over speeding, drunk driving, red light jumping, careless or attention-deficit while driving and others. The increasing number of the vehicle on the road that results in traffic jams may also increase the occurrence of road accidents. Statistics from the Department of Road Transport Malaysia (JPJ) indicated that there were about 583060 cars registered in JPJ in the year 2013 [2]. In science, one of the causes of road accident is the loss of attention or attention deficit during driving. The attention deficit is one of the examples of Habituation Phenomenon.

Habituation phenomenon is a natural phenomenon experienced by human and animals. Habituation phenomenon refers to the repeated presentation of an auditory stimulus from the healthy human, which is decreasing over time [3]. One of the examples of the habituation is attention drifting/deficit during driving. A study from the University of Bordeaux in France has reported that among nearly 1000 drivers injured in an accident, 52% reported the occurrence of attention drifting before crashing their cars [4]. In addition, previous researcher discovered that the attention drifting is a life-long disorder, which has also been associated with road accidents [5]. These evidences indicate that the attention drifting is one of the factors that cause road accident.

Attention drifting could be measured by using electroencephalogram (EEG). The EEG is the signal commonly used to detect the epileptic seizures, which are the result of abnormal electrical activity in the brain [6]. EEG provides a method to investigate the general function of the brain, including its reaction to particular stimuli that will be represented as changes in the EEG, globally known as event-related potentials (ERP). In this study, the EEG will generate signals using the BIOPAC medical bio-signal amplifier. BIOPAC is a modular device for recording physiological signals such as EEG, ECG, EOG, EMG and respiratory signals.

ERP is defined as the brain response that is triggered by the occurrence of a particular stimulus, such as auditory, visual, and somatosensory. ERP has several components, such as the N100 wave and N170 wave, which will react the auditory stimulant and visual stimulant respectively. In previous research, Naatanen and Picton proposed that the N100 wave (auditory) and N170 wave (visual) reflect sensory and physical properties such as the intensity [7]. In this study, attention deficit is examined by N100 wave. Specifically, the subject of this study will be stimulated by a non-stimulant and a verbal stimulant (speech recorded).

Soininen et al. [8] reported that the habituation of the N100 wave does not depend on the age. According to them, the recording of the N100 wave habituation is simple. In addition, N100 wave does not require good cooperation of the subject as in the case of the cognitive oddball paradigms used for the P300 wave measurements. Since the N100 wave is normally the largest component in the response to auditory stimuli, it has a good signal-to-noise ratio. N100 wave is always clearly discernable in the responses of normal subjects due to physiological cause. Several studies have shown that the decrease in the amplitude of the N100 wave was insignificant when the stimulant intensity was intense and significant to the subject, particularly when they were told to pay attention to the stimulant. However, the findings were not strong and seem to depend on the experimental conditions used. Tone [9], click

[10] and chirps [3] are some of the usual stimulants used in above-mentioned studies. These stimulants are non-verbal stimulants and they are meaningless. Previous research offer conflicting suggestions whether the "high-priority" verbal stimuli such as an individual's own name or emotionally charged words can automatically grab the attention and/or can be detected without the usual capacity limitations as stated in [11]. In addition, an insignificant decrease of N100 wave was found when a high-intensity stimulant was used [9].

Speech is one of the examples of meaningful sound. Speech can affect the performance of human driving. Research from Mark Vollrath [12] discovered that the drivers encountered less risk of accident when listening to the passenger's small talk, argument and speaking. This means that when drivers listen to something, the attention of driving is higher. Although speech also can interrupt the attention of driving, previous research had discovered that the speech have only a small effect to the drivers, while driving. Therefore, using and analyzing the EEG output responses, this study aims to investigate whether speech practicability can avoid the attention deficit. Meaningful sounds, such as recorded speech and no sound will be used in this experiment.

II. METHODOLOGY

A. Flowchart: EEG

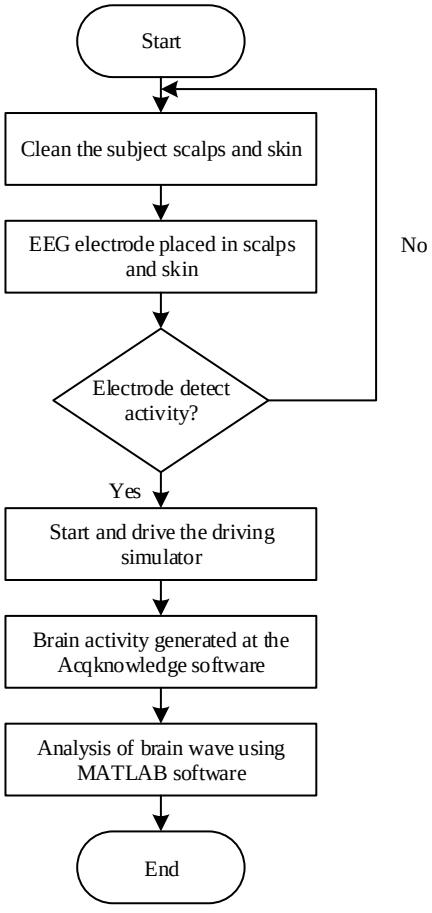

Figure 1: EEG Simulation flowchart

Figure 1 shows the flowchart of EEG simulation. The EEG simulation begins with the preparation of the subject, in which the scalp and skin of each subject need to be cleaned by using alcohol to remove dead skin or scalps cell. Then, the EEG electrode is placed at the scalps. The ground electrode is placed at the center of a skull (vertex) labeled Cz, the positive electrode is placed at the temporal bones (mastoid) labeled as Ag/AgCl and the negative electrode is placed on the forehead. The Acqknowledge software is used to check whether the electrode is functioning. If the electrode is detected functioning (Yes), the subject will start and drive the driving simulator. In parallel, the brain activity will be generated at the Acqknowledge software. If the electrode is detected not functioning (No), the initial step will be repeated. Then, the simulator will be started and in parallel, the brain activity will be recorded. The brain wave activity (N100 wave) generated or recorded at the Acqknowledge software is analyzed using MATLAB software.

B. Subject

This study involved seven healthy hearing and visual young adults with valid driving license (age within 18-20). This is to establish the basis or the benchmark of the normal condition without any other influences.

C. Experiment Setup

The ERP setup consists of a computer to generate the stimuli, a trigger box to mark the occurrence of the stimulus, a biosignal amplifier for data acquisition and a monitor for visual stimulation. Driving simulation is displayed in front of the subject. The subject is stimulated by no sound and recorded speech and the responses will be recorded using BIOPAC Biosignal System. The electrodes (Ag/AgCl) are placed at the left and right mastoid, the upper forehead (negative electrode) and the vertex (Cz) for ground electrode. Figure 2 shows the complete equipment for the conducted experiment.

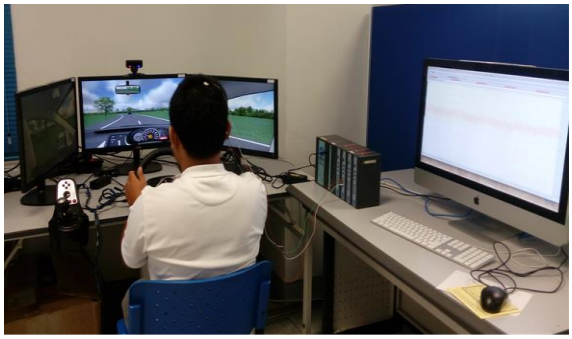

Figure 2: The complete equipment for the simulation.

This experiment has two parts of simulations. In the first part, the driver is stimulated without no sound while he is driving on the highway about 20 minutes. The subject's response (brain wave) will be recorded in the ERP system. The highway task consists of the basic of driving i.e. entering; leaving the highway, overtaking in a traffic jam condition.

After a few minutes rest, in the second part, the driver will be stimulated by a recorded speech while driving on the highway and the subject response will be recorded in the ERP system. In parallel, the driving simulation system will generate the

data/diagnostic for each part of the experiment.

D. Analysis

These output responses of N100 wave were analyzed based on the post recording using MATLAB software. The decrement of amplitude for each subject was done by differentiating half of the average peak of the end response and half of the average peak of the early response (let be present by [D=mean {average$_j$: j= 1, 2,…, Q}] - D=mean {average$_j$: j= Q/2+1, Q/2+3, …, Q}] where Q is a total of averaged groups obtained after the averaging process.

III. RESULTS

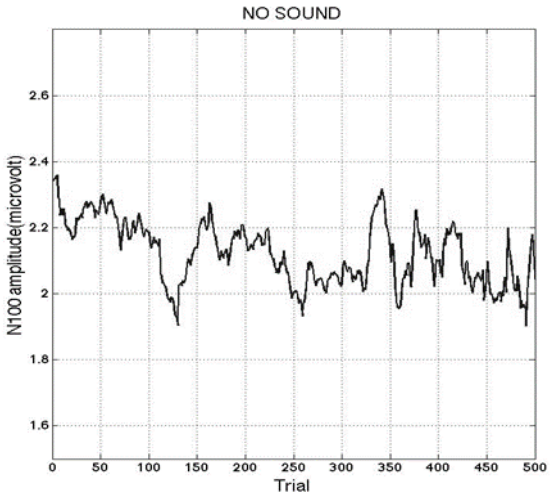

Figure 3: The average result of N100 amplitude for no sound simulated responses

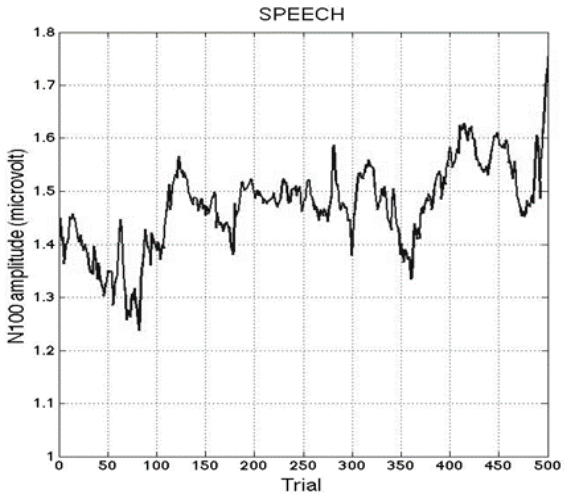

Figure 4: The average result of N100 amplitude for recorded speech simulated responses

Figure 3 and Figure 4 are the average results N100 amplitude for no music simulated and speech simulated respectively. From Figure 3, the trend of N100 wave indicated a gradual decrease over trial in comparison to Figure 4. In Figure 4, the trend of N100 amplitude gradually increases over the trial.

In the gross perspective, driving without meaningful sound (no sound) can affect the driving attention that can cause the driver to be less vigilance. In other words, the attention drifting or habituation will occur when no sound or free meaningful sound stimulates the driver.

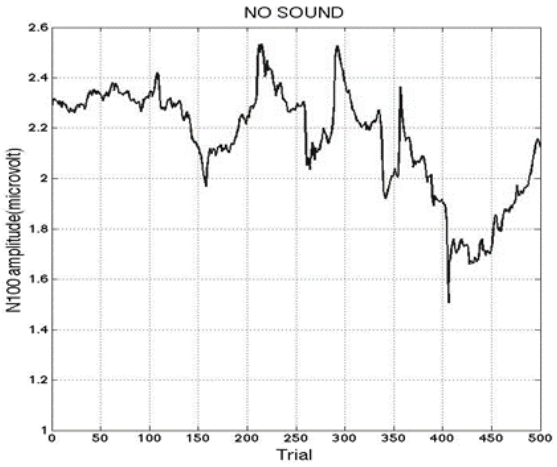

Figure 5: The example of individual result for no sound simulated responses (subject 6th)

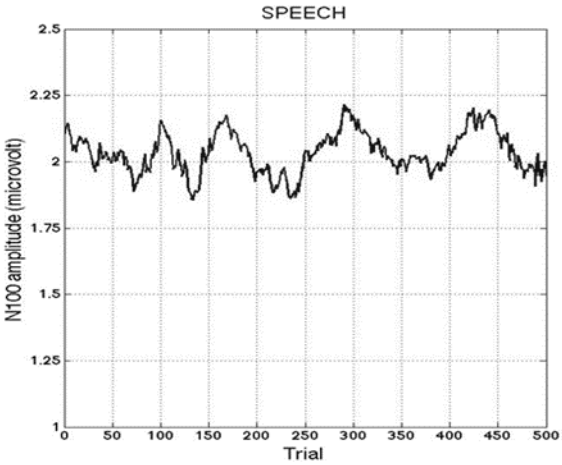

Figure 6: The example of individual result for recorded speech stimulated responses (subject 6th).

Figure 5 and Figure 6 are the individual result of the 6th subject for no sound and speech simulated respectively (random selection). Figure 5 indicates that the N100 trend is decreasing over the trial, while Figure 6 indicates a more stable trend for N100 amplitude.

This study shows that meaningful sound can result in a more vigilance or focused driving performance. In addition, the results show that meaningful sound is a practical approach to avoid attention drifting and can reduce accident.

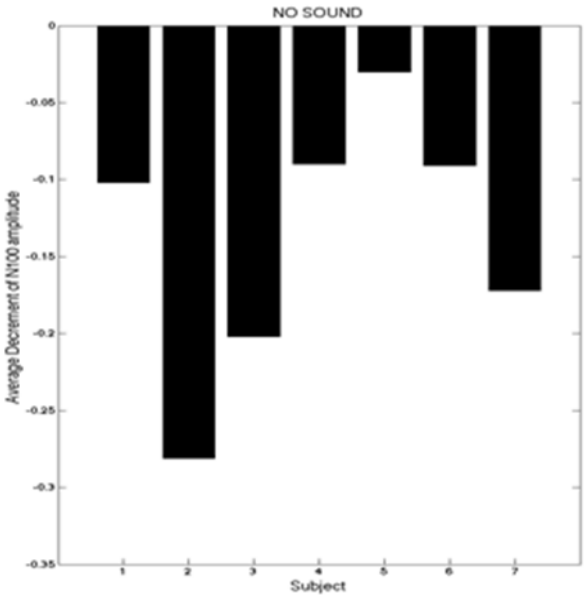

Figure 7: The average decrement of N100 amplitude each subject for no sound simulated responses for each subject

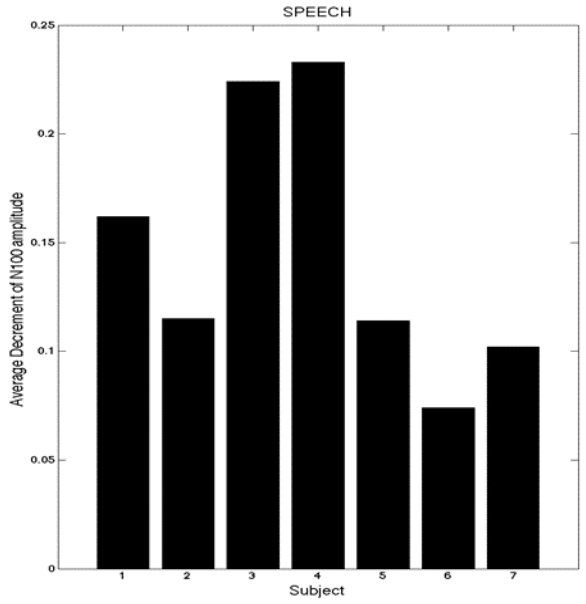

Figure 8: The average decrement of N100 amplitude each subject for recorded speech simulated responses.

Figure 7 and Figure 8 show the decrement of N100 amplitude of each subject for no sound and recorded speech simulated responses. The decrement is obtained by deducting one half of the average peak of N100 amplitude of early responses of the experiment to one half of the average peak of N100 amplitude of end responses of the experiment. As expected, when the responses are habituated over time, the decrement will be negative as shown in Figure 7. However, if the responses are not habituated over time, the decrement will be positive as shown in Figure 8. Based on Figure 7 and Figure 8, driving with no sound has less vigilance. Hence, there is a tendency of drifting or habituation to occur in comparison to driving while listening to recorded speech. This shows that meaningful sound have a strong effect on driving performance with positive behavior.

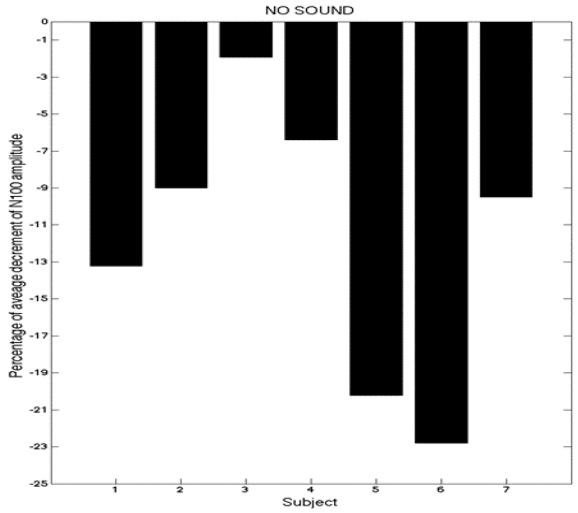

Figure 9: The percentage of average decrement of N100 amplitude for no sound simulated responses.

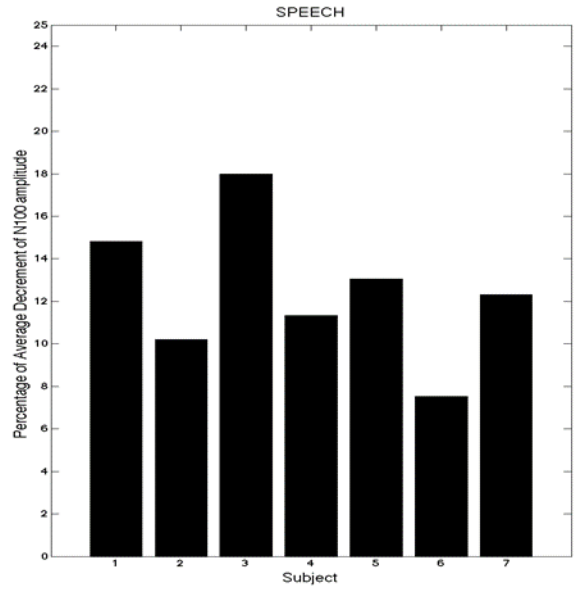

Figure 10: The percentage of the average decrement of N100 amplitude for recorded speech simulated responses.

Figure 9 and Figure 10 indicate the percentage of the average decrement of N100 wave for the no sound simulated responses and the recorded speech simulated responses respectively. Figure 9 (no sound) shows the negative percentage of the average decrement of N100 amplitude. A negative percentage means that the subject is experiencing attention drifting (habituate) and less vigilance during driving. As indicated in Figure 10 (speech recorded), the positive percentage means that subject does not experience attention drifting while driving and more focus or vigilance during driving.

IV. Discussion

Meaningful sound can be examined as the stimulants, which can avoid the occurrence of the habituation phenomenon during the driving. It correlates to the previous research that stated that voice interaction could increase the safety of driving by avoiding driver's distraction [13]. It can be proven with the trend of N100 amplitude in Figure 4, which showed that N100 amplitude gradually increases over the trial.

Based on the result shown in Figure 3 and Figure 5, the driver has less concentration and is experiencing habituation during driving when there is no meaningful sound. This condition may lead to the occurrence of road accident. The absence of entertainment and other positive influences during driving result in the driver feeling boring, leading to the lack of vigilance. In the worst conditions, this may result in road accident in comparison to listening to the meaningful sound.

Based on Figure 10, a percentage of average decrement of N100 is positive. This result indicates that the subjects are more focused and pay attention during driving. The subject's attention increases to 7% (minimum) when driving with meaningful sound (speech recorded). However, at least 2% of the subject's focus has diminished, while driving with no sound, as shown in Figure 9. Thus, it can be concluded that the recorded speech is a practical way to avoid the occurrence of attention drifting phenomenon (habituation).

As shown in Figure 8, all the subjects have positive N100 amplitude decrement. This result shows that the driving performance increases when driving is contextualized within meaningful sound. Previous researchers have discovered the positive behavior during driving, in which the matching of another voice or speech could make positive behavior to the driver [14]. Consistent with the findings of the previous research, the positive behaviors influence the entire subject.

In addition, speech can interrupt the attention of the driver. However, previous researchers have discovered only minimal interruption and bad effect to the driver's attention [15]. However, this study shows there was no interruption to the subjects while driving with speech stimuli.

V. Conclusion

Speech recorded could be used as one of stimulants to avoid the occurrence of habituation (attention drifting), leading to decrease in the occurrence of accident while driving. This study has proven that at least 7% increase in the attention of the subjects while driving with meaningful sound (recorded speech).

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